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ABSTRACT

A review of literature related to rate of reading and auding, primarily in non-remedial high school and adult readers, is provided in this paper. After offering a definition of reading, a discussion of those studies which examine rates of reading and auding separately is provided with a summary of studies which directly relate rates of reading and auding. Critical problems in testing language comprehension are considered in relation to the studies mentioned. The author concludes that the norm rate of reading is approximately 185-300 words per minute (WPM), while the norm rate of auding is about 125-200WPM. The maximal rate of auding may be somewhere in the range from 350-450 WPM, but it may be affected by loss of intelligibility of the speech signal. Conflicting evidence exists on a maximal rate of reading. Studies which directly compare rate of reading versus auding reveal little difference between modalities. (Author/KS)

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Rate of Reading and Auding

Qualifying Paper

Harvard University
Graduate School of Education

submitted by

Robert Fulmer

May 1976

CS 002 767

Abstract

This paper reviews several bodies of literature related to rate of reading and auding. For the most part, only studies dealing with non-remedial high school and adult readers are reported. After offering a definition of reading, the paper reviews those studies which examine rate of reading or auding separately, then those few studies which directly compare rate of reading versus auding. After discussing similarities and differences between the two stimuli, it is concluded that the similarities are great enough to make valid reading-auding comparisons. Finally, some critical problems in testing language comprehension are considered; how these problems affect the results of the reviewed studies is discussed. The author concludes that the norm rate of reading is in the neighborhood of 185-300 words per minute (WPM). The norm rate of auding is about 125-200 WPM. The evidence for maximal rates is not as conclusive. The maximal rate of auding may be somewhere in the range from 350 to 450 WPM, but may be affected by loss of intelligibility of the speech signal. There is conflicting evidence on a maximal rate of reading. For those studies directly comparing rate of reading versus auding, there is little modality difference.

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Introduction

Purpose of the Paper

The specific question addressed is: what are norm and maximal rates of silent reading and auding[1]? To answer that question, I will review the literature related to:

1. rate of reading and auding.

2. modality efficiency of reading versus auding.

The most detailed emphasis in this paper is on those few studies which have directly compared rate of reading with rate of auding (reviewed in Section V). Other sections of this paper are seen as a foundation for understanding this section, and the review of studies in these sections receives less emphasis.

Basically, only the literature dealing with non-remedial high school, college, and adult subjects will be covered, to increase the probability that subjects will have fully-developed decoding skills. Lack of fully-developed decoding skills is seen as a confounding factor, since reading rate could be affected by a relatively slow decoding process.

Significance of Studying the Problem

This review is seen as a basis for future experimental studies on the effect of rate of reading and auding on comprehension. The significance of these studies is related

[1]The term auding is used throughout this paper to refer to the process of listening to speech to understand the thoughts presented by the speaker. While it may seem like jargon, the term is necessary to distinguish listening to speech from listening to non-language stimuli. In other words, reading is to looking as auding is to listening (Sticht, Beck, Hauke, Kleiman, & James, 1974).

to theory as well as to practice in education. The following points are seen as some of the contributions such studies could make.

1. Rate is one of the measurable dimensions of the auding and reading processes. It seems that rate must be taken into account when theorists of verbal information processing discuss various aspects of the processing mechanism.

2. Another source of interest is concerned with describing a comprehension/rate tradeoff. That is, does a rate increase result in a comprehension decrease?

3. Is there any evidence from comprehension/rate curves of a threshold, a rate beyond which decreasing comprehension accelerates? What is the significance of a threshold?

4. Other than stimulus differences, differences in rate/comprehension curves during reading, versus rate/comprehension curves during auding, must be accounted for by efficiency of processing. If language comprehension is a central process, why should one modality be more efficient?

5. Studies might yield some insight into <u>maximal</u> rates of input in comprehending verbal material, using some arbitrary criterion of acceptable comprehension (such as 70% performance on a multiple-choice posttest of factual information contained in the text).

6. Studies might give an idea of <u>optimal</u> rates of input for comprehending verbal material for different populations, purposes, and materials. In other words, if efficiency is thought of as rate times accuracy (Carver, 1976), what rate will facilitate comprehending the most in the shortest pre-

sentation time?

7. How do any of the above vary with individuals, populations, purposes, and materials?

Answers to the first four points would contribute to the field of human information processing. Answers to points five and six should prove useful in education, particularly in the design of verbal materials, such as audio-taped passages. The last point is important in both fields.

This paper promises no answers to the above issues. It is a review of completed studies which bear on the rate of reading or auding.

A Developmental Model of Literacy

My interest in the area of reading and auding rate was sparked by a recent developmental model of the reading/writing, auding/speaking processes (Sticht, Beck, Hauke, Kleiman, & James, 1974). The heart of the model, as it relates to reading, appears below.

> The major thesis of the developmental model of reading which we are constructing is that the person comes into the world with certain basic adaptive processes which he uses to build a cognitive content and to acquire language competency. The bulk of this competency is verbal language competency, acquired and expressed by auding and speaking, respectively. In learning to read, the child uses the same cognitive content and languaging[1] competencies used earlier in auding, plus the additional competencies involved in decoding print-to-language. (p. 114)

Sticht et al. derive four testable hypotheses from this theory; one of these leads directly to this literature review.

[1]Languaging is the representation of conceptualizations by properly ordered sequences of signs (in speaking or writing), or the inverse process of understanding the conceptualizations underlying the sequences of signs produced by others (in auding or reading), according to Sticht, et al.

This hypothesis states that "performance on measures of rate of auding and rate of reading will show comparable maximal rates of languaging and conceptualizing for both processes, assuming fully-developed reading decoding dkills" (p. 72). Since the theory states that auding and reading use the same language and conceptual bases, these bases should limit both auding and reading rates. They claim that auding and reading are merely different modality names for channels with which to access languaging and conceptualizing abilities.

Overview of the Paper

First, I will advance a definition of reading, and then I will present a review of studies on rate of reading (with insights into reading strategies from studies of eye movements and visual acuity). Next will come a review of rate of auding studies, followed in the next section by a review of the few studies which have specifically examined rate of reading versus rate of auding. Two major problems with research on rate of reading or auding are then explored: stimulus differences, and problems of assessing comprehension. Finally, the results of studies are summarized and conclusions are drawn from these results.

II. A Definition of Reading

The Problem

Basically, the literature reveals two groups with distinctly different views of a definition of reading. One group feels that looking at all the words is a necessary condition for reading (along with comprehension), while the other group feels that perhaps looking at all the words is not necessary for reading. Both groups embrace the idea of reading as a language comprehension activity. While the two views are not mutually exclusive, the latter view is much broader in the sense that a reader may utilize more strategies, and still be said to be reading.

Definition by Comprehension, Plus Looking at All the Words

This group feels reading can occur only when the eyes cover all, or most, of the words on the page. Thus, Spache (1962) says, "if we interpret the term in the common understanding of reading most of the words on a page, it is impossible to read faster than 800-900 words per minute.... Any speed greater than this involves omitting lines, the technique recognized by most authorities as skimming, not 'reading'" (pp. 259-260). Carver (1971) and Sticht et al. (1974) also feel that skimming is not reading, because some of the text is skipped. This group uses eye movement studies of readers to show two different activities: one of which the authors define as reading, the other which they define as skimming.

Definition by Comprehension

This group generally emphasizes the acquisition of meaning from writing, and does not emphasize looking at all the words.

> Reading means acquiring the intended meaning from printed or written symbols. Whether this process necessarily requires seeing every word with greater than 50% acuity is a matter for empirical investigation. (McLaughlin, 1969, p. 451)

Without quoting further, it will be noted that Carroll (1970), Goodman (1970), Mackworth (1971), Smith (1975), and Witty (1969) have also stressed the comprehension aspect of reading.

A Reading-Auding Analogy

What is the resulting observable behavior of reading -- eye movements (indicating the words looked at) or performance on a comprehension test, or both? Eye movement photography can indicate what percentage of text is actually being looked at by the reader. It does not indicate to what extent the reader is comprehending the text.

The method of determining whether (and how well) a person is auding is by giving a comprehension test after auding. This is the basis of standardized auding tests as well as the tests given in college courses after weeks of lectures. If a person was auding, some learning (resulting from comprehension) should have taken place which could be reflected in performance on a comprehension test. Poorer auding should result in a lower score than better auding. It seems that a definition of auding rests on language comprehension, just as a definition of reading must rest on language comprehension.

Eye movements happen to be handy, observable behaviors

which accompany reading. Just as regular eye movements do not insure comprehension by reading, movement of the small bones in the ears does not insure comprehension by auding. Both are necessary, but not sufficient, conditions for comprehension by reading or auding.

Reading for a Purpose

Any definition of reading has to take purpose into account. Reading can be seen as a cluster of behaviors, dependent upon purpose. Not all reading demands very accurate comprehension.

Reading purposes may be thought of on a continuum. At one extreme is a person reading a pithy detective novel for enjoyment while waiting several hours for an overdue flight (Gibson & Levin, 1975). The reader is interested (perhaps to a small degree) in following plot development; he knows there will be no comprehension test. In short, the reader has nothing to risk. At the other extreme is a bomb squad worker who is by himself with a live bomb and reading directions in a manual on how to defuse it. His purpose is to read for total comprehension because he will be taking a serious comprehension test where he has a lot at stake. He is risking his life on very accurate comprehension.

Other reading purposes fall somewhere in between these extreme cases: reading an assignment, reading a poem for enjoyment, looking up a name and number in a phone book, reading an article as an editor (who will be held accountable for correct punctuation, spelling, and style), and scanning an encyclopedia article for the liftoff date of the first

rocket. In short, some reading purposes require very accurate comprehension, some do not.

> The word "reading" is ordinarily used to refer to many different and only loosely related perceptual skills -- we proofread one way, we memorize another way, and we comprehend still another way; then we go on to read for amusement, or translate from another language, or skim for an overview, or puzzle out a handwritten message, or search for a target, or read aloud to others, or lull ourselves to sleep, or read a label on a bottle in the medicine cabinet, or worship our gods, or sing our verses. (Miller, 1972, p. 377)

A Stipulative Definition of Reading

For purposes of this paper, I will define reading as a process of comprehending language through print, regardless of the amount of words looked at. The accuracy of comprehension depends upon reader purpose. Reading is a means to an end -- communication between the writer and the reader -- and it is around this concept that a definition must be built. Communication involves comprehension on the part of the reader. Eye movements are useful in determining the extent to which a reader samples a text. Using this definition, we may divide reading into two main strategies:

1. Inclusive reading. The reader looks at all the words of the text. Generally, his purpose is to comprehend as much as possible.

2. Skimming.[1] The reader looks at less than all the words of the text. The size of the text sample depends on purpose, which may be affected by time constraints and

[1]It is acknowledged that the term "skimming" is sometimes used differently in the reading literature (Harris & Sipay, 1971; Tinker, 1965).

acceptable level of comprehension accuracy.

This definition has been developed because, in measuring reading rate, there has been a debate over the reading rate: words actually looked at per minute, or words covered per minute. And many studies of reading rate contain no information about reader comprehension, a variable I feel should be required to determine whether, and with what accuracy, Ss were actually reading. We follow Tinker's (1962) thinking that in studying reading rate, "the only justifiable or valid definition of 'speed of reading' is 'speed of comprehension'" (p. 10).

III. Rate of Reading

Overview

This section of the paper will deal with norm and speed rates of reading, reading comprehension/rate tradeoff, and the relevant eye movement and visual acuity research.

Butterflies

It seems that, quite often, theorists in reading and human information processing feel they are forced to explain the alleged phenomenon of the ability of some people to read at high rates. They construct theory to take speed readers into account. Sometimes, they do so without referencing or documenting the existence of these people. The following quotes are a butterfly collection of some of these statements, none of which were accompanied by references.

> A person who reads at 2,000 or 20,000 words a minute is surely not identifying every word on the page.... Rapid reading represents an achievement as impossible in theory as it is commonplace in practice. (Neisser, 1967, pp. 108, 137)

> And of course it is impossible that reading at 2,000 words per minute or more be dependent on auditory representations because auditory representations cannot be formed so quickly. (Kolers, 1970, p. 115)

> An efficient reader may read text for meaning at up to 4,800 letters per minute.... Comprehension scores may be very high. (Hochberg and Brooks, 1970, p. 304)

> How can we explain the very high speeds at which some people read? (Mattingly, 1972, p. 143)

> People do speed read, and they have very good comprehension. Yes, it is true that we can compute that maximum reading speed is someplace between 500 and 900 words per minute. (Norman, 1972, p. 156)

> Consider the fact that a skilled reader can read with comprehension at rates of more than 1,000 words per minute.... The data rate of such performers is truly

> awesome; it represents an irresistible challenge to theoretical explanation. (Bower, 1970, p. 135)

What does the literature present as norm and maximal rates of reading, and how is comprehension affected by increasing rate?

Norm Rates of Reading

Following our definition of reading, it is necessary to ascertain comprehension as well as rate. Rate by itself is meaningless (Davis, 1962). Unfortunately, the great majority of studies on reading rate seem to be more concerned with rate than with comprehension.

Huey (1908) reported on 20 graduate students who were asked to read an interesting novel which was not difficult. Their normal rates ranged from 150 to 588 words per minute (WPM). When asked to accelerate their reading, rates ranged from 210 to 810 WPM. In this informal observation, no comprehension check was given.

Tinker (1962) notes that for a seventh grader reading easy material, 400 WPM is very high. For college students, 600 WPM is very high, and 850 WPM is exceedingly rare. For well-educated adults, rates of 500-600 WPM are fairly common. Gibson and Levin (1975), after reviewing the literature, state that average adults read 200-400 WPM, usually nearer 200 WPM. Earl Taylor (1957), while studying eye movements of over 5,000 Ss, reports mean rate for fourth-graders as 180 WPM; for college students as 340 WPM.

There have been two large studies of norm reading rates which have made efforts at assessing rate as well as comprehension on material of known difficulty level. Stanford

Taylor (1962a) studied eye movements and rates of 12,000 Ss, at every level from first grade to college. All Ss read material, appropriate for their grade level, at 70% comprehension. The following table shows the regularity with which mean rate increased.

Table 1

Mean Reading Rate at Each Grade Level

Grade	1	2	3	4	5	6	7
Mean rate (in WPM)	80	115	138	158	173	185	195

Grade	8	9	10	11	12	College
Mean rate (in WPM)	204	214	224	237	250	280

(adapted from Taylor, 1962a, p. 42)

The Education Commission of the States (1972) conducting the National Assessment of Educational Progress on Reading Rate and Comprehension studied 7,850 Ss in four groups: 9-year-olds, 13-year-olds, 17-year-olds, and young adults (26-35 years old). Each group read two passages, and were tested for recall of details with 5 multiple-choice items after each passage. The difficulty levels in grade equivalents of the passages, estimated by several readability formulae, are listed in Table 2, page 13. It should be noted that Passage II always had a difficulty level higher than S's grade placement. And the difficulty level of Passage I for the 9-year-olds was still about two years above their grade placement. No rationale is offered in the report for studying rate and comprehension on material which

Table 2

Passage Difficulty Levels, in Grade Equivalents, for the Four Groups in the National Assessment of Reading Rate and Comprehension

Group	Passage I	Passage II
9-year-olds	6.5	10.5
13-year-olds	5.5	11.0
17-year-olds and young adults	10.5	College

is quite difficult for readers.

The results are summarized in the following table.

Table 3

Reading Rate and Comprehension of the Four Groups in the National Assessment of Reading Rate and Comprehension

	Rate (WPM)		Comprehension % of Ss with 4 or 5 questions right	
Group	median	range	Passage I	Passage II
9-year-olds (N=2195)	120	0-1302	73.4	31.5
13-year-olds (N=2196)	169	0- 991	40.2	34.9
17-year-olds (N=2220)	195	0-1771	66.7	31.4
Young adults (N=1239)	187	0- 859	68.8	43.2

It is not explained how a rate of zero WPM was obtained, although each of the four groups contained at least one S "reading" at this rate. All of the highest rates in each group were attained on Passage II, even though it was more difficult than Passage I. This may reflect an attitude on the part of the readers not to attempt to comprehend difficult material, but just to rush through it as soon as possible.

As for comprehension at higher rates, there were 17 Ss (out of 7,850) who read either passage faster than 750 WPM. If a comprehension criterion of four right answers (80%) was required, only 5 of the 17 Ss would have passed the criterion on one passage. None would have passed the criterion on both passages.

It should also be noted that a comprehension score, which would make rates more meaningful, is reported in only two of these studies. And in these, the instrument is not described (Taylor, 1962a), or it is a non-standardized measure of comprehension (National Assessment data). It is difficult to draw conclusions about accuracy of comprehension at norm reading rates.

The above studies indicate how fast different readers do read, not how fast they can read. Rate will be influenced by difficulty of material and reader purpose. From these studies, it appears that norm reading rate is in the neighborhood of 185-300 WPM. This is corroborated by the mean adult rate of the norm sample of the Nelson-Denny Reading Test: about 250 WPM (Carver, 1971).

Maximal Rates of Reading

Much of the literature has debated whether speed readers are reading inclusively or skimming. The evidence to be presented indicates that speed readers are indeed skimming. The question then becomes, what happens to comprehension as the sample of words from the text becomes less?

Carver (1971), after reviewing the speed reading literature, found that treatment description and data collection

accounting are usually unsatisfactory. A researcher needs to know:

1. reader familiarity with the material.
2. nature and difficulty of the material.
3. the details of the method used to measure comprehension.
4. if the reader took the reading rate test before.
5. if the reader graded his own test.

Many of these points are not covered in studies of speed readers. Cases in point are reports by Witty (1969) and Stauffer (1962) of high school and college reading rate clinics where Ss increased rates up to 900 WPM. Comprehension tests are not mentioned. Following the definition of reading in this paper, comprehension scores are necessary to make reading rates meaningful. If comprehension scores are below chance level, it really makes little difference if the reader was "reading" at 300 WPM or 3,000 WPM.

An interesting point regarding norm and maximal rates of reading is made in a study by Laycock (1955), cited in Davis (1962). Out of 391 applicants for a college, the fastest readers (with comprehension scores > 75% on a rate test) were able to approximately double their reading rates merely by being asked to read rapidly on a second form of the test. There was little or no loss in comprehension scores. So here it seems that reading rate for a college population can be doubled, with no loss in comprehension, without any training at all.

There has been a great deal of discussion about speed

reading courses. Evelyn Wood Reading Dynamics is perhaps the most well-known and studied. Wood (1960) began by timing and checking the comprehension of about 50 people who read 1,500-6,000 WPM. Their present brochure ("How to Read," undated) notes that these natural speed readers:

1. absorbed complete thoughts, as much as a paragraph at a glance.

2. never re-read.

3. didn't read out loud or silently to themselves.

4. exhibited flexibility (a 3,000-WPM reader might drop below 1,800 WPM for technical material).

5. had exceptional concentration; they could recall information whenever needed.

The brochure claims that "every word is read... and every word is understood" (p. 6). It promises to be a very fast inclusive reading strategy, attained by increasing the span of vision to the width of a page. A recent advertisement claims their graduates "have at least tripled their reading speed with equal or better comprehension" ("Stop Reading," 1976).

Carver (1971) took the course and reported on it. The three main principles were:

1. read down pages instead of across them.

2. read in thought patterns, whole concepts, and ideas instead of one word at a time.

3. use the hand as a guiding pacer.

Previewing was very important, including stating the purpose for reading. Students practiced "threading," which is

apparently skimming for the main idea only, following the hand as a pacer. They also learned the SQ3R method of study skills, which really meant skimming the passage four times:

S) survey

Q) question

R) read rapidly

R) read for understanding

R) re-read for review.

Actually, a great deal of re-reading of material was done in all practice sessions, something Carver feels may have contributed to a sense of adequate comprehension, and something Wood noted natural speed readers never did. Carver's overall impression of the course was that it taught skimming skills, and skimming results in decreased comprehension and enjoyment.

A doctoral dissertation by Liddle (1965), reported and discussed by Carver (1971), evaluated the Wood Reading Dynamics method. Of 50 college juniors, half were randomly assigned to the speed reading instruction, and half took only the pre- and posttests. The test material was The Pearl, a relatively easy, well-known novel by Steinbeck; and two chapters from a sociology text. Multiple-choice items which tested recall of fact, ability to inference, and ability to reflect critically were written for every 150-200 words of text. The two groups were comparable on the pretests, but the speed readers increased their rates on the posttest to about five times faster than the control group. On the fiction posttest, the speed reader scores were significantly lower

on fact and inference items, but higher on critical reflection items (none of the differences were significant for any of the three types of items testing the non-fiction). This study indicates that speed readers are apparently missing some details, and consequently may be unable to use details to draw inferences on fiction. But comprehension holds up on non-fiction.

Taylor (1962a) studied 41 Reading Dynamics graduates' rate and comprehension on standardized passages and a novel. Mean rate on the passages (administered before and after the course) increased from 474 to 564 WPM; comprehension scores increased from 78% to 81%. The significance of this difference was not tested. Eye movement data indicated Ss were largely reading inclusively during both administrations of the passages.

But they read the novel "dynamically," (posttest only) at a mean rate of 2,509 WPM. The mean comprehension score on the 25 true-false questions following the novel reading was 49%, or slightly below chance level. This suggests no comprehension, or information gain, at 2,500 WPM. Even while reading at this rate, fixation durations were normal.

Spache (1962) obtained almost exactly the same results from a similar study. He studied the eye movements, reading rate, and comprehension of an unspecified number of Reading Dynamics graduates before and after taking the course. The materials were (a) the test selection supplied with the eye movement camera, and (b) a book. In both cases, comprehension was measured by a true-false test. Spache found that the

rate gain on the first selection ranged 20-25%, with post-test rates generally in the 400-600 WPM range. Comprehension scores were "normal" (70% or better), and gained less than 5% after training. However, while reading (skimming) the book for the posttest, rates were generally in the 1,800-2,400 WPM range, and mean comprehension scores were 50%, or chance level.

It is difficult to describe a comprehension/rate trade-off from the Taylor and Spache data since the material and comprehension questions were different for the slow and fast rates. Also, it is not possible from the studies to determine the mean gain in rate or comprehension scores when they were reading the second set of materials (books). It is possible to say that some people are capable of reading inclusively at rates from 400 to 600 WPM, at least on some passages, with comprehension scores above 70% on a true-false test. When these same people read books at rates 1,800 to over 2,500 WPM, mean comprehension scores are at chance level.

An example of a case study is that of McLaughlin (1969), who studied the reading of a female college graduate, with an IQ of 140, who worked as a scientific editor. She read a novel at 10,000 WPM. During the comprehension check of un-aided recall, she recalled a number of details, but only 6 of the 24 main points on a published summary of the plot. Then, after reading a projected novel at 3,500 WPM, she had "much more satisfactory recall, although she ... missed a central point" (p. 502). Finally, she read the publisher's proof of a book not then available. The rate ranged from 1,200 to 9,000 WPM, with a mean of 3,750 WPM. Her recall of seven

consecutive pages is compared to a synopsis of the same pages; it seems quite accurate, but we have no way of knowing if the comprehension of the whole book was as accurate. Her fixation durations were normal. Since she made only 5 to 14 fixations per page, she was using a skimming strategy, not reading inclusively.

These studies appear to be the only scientific studies on maximal rates of reading. There are many reports of speed readers which have not been included because comprehension is not reported.

To this author's knowledge, Liddle's (1965) study is the only experiment (random assignment to treatments) looking at high rates of reading. It is perhaps in this study that the most faith should be placed. The results showed that speed readers' mean comprehension scores were significantly less than control group readers' scores on fiction, but not significantly less on non-fiction.

Perhaps several valuable aspects of speed reading have not been studied. Speed reading may be the most efficient strategy to preview and review material, as well as to help the reader decide what is relatively important to read for his purpose. Study is needed to understand the relationship between speed reading and normal reading.

> I took a course in speed reading, learning to read straight down the middle of the page, and I was able to go through War and Peace in twenty minutes. It's about Russia! (attributed to comedian Woody Allen by Hultgren, 1968, p. 13)

Comprehension versus Reading Rate

There are two ways to describe any comprehension/rate

tradeoff: (a) what happens to comprehension as one reader increases reading rate, and (b) what is the correlation across Ss of comprehension scores with their own reading rates? There are only a few studies which manipulate reading rate to answer the former question; those studies will be discussed in detail in Section V, on rate of reading versus auding. For now, we will just summarize those studies by noting that comprehension seems to decrease roughly linearly with increasing reading rate.

Many studies have studied the second question, and come up with correlations ranging from -.47 to +.96 (between comprehension scores and reading rates across Ss), according to Rankin's (1962) review of 16 studies. Rankin maintains that almost no studies have controlled for the reader's purpose. When the materials become more difficult, when there are no time limits on reading or comprehension tests, when more critical thought processes are involved, and when reader purpose is more exacting, "the relationship between reading rate and comprehension is minimal" (p. 5). The rate/comprehension relationship for reading, despite years of study, has not been established.

Eye Movements and Acuity of Vision

This section will deal with eye movements of inclusive readers, acuity of vision, and eye movements of speed readers. Since eye movements are the only overt behavior accompanying silent reading, they do provide information about reading strategies.

It will be useful at this time to define the terms to be used in the following discussion:

Fixation - where the eyes come to a stop on a line of text.

Fixation duration - the amount of time the eyes stop.

Saccade - the movement of the eyes from one fixation to the next.

Perceptual span - the width to the left and right of a fixation from which usable information can be obtained.

Regression - a saccade from right to left on the same line.

Return sweep - moving the eyes from the end of one line to the beginning of the next line.

Taylor (1962a) offers the following developmental data on eye movements, based on records of 12,000 inclusive readers.

Table 4

Average Measurable Components of the Fundamental Reading Skill

Grade	1	2	3	4	5	6	7
Fixations	224	174	155	139	129	120	114
Regressions	50	40	35	31	28	25	23
Perceptual span (in words)	.45	.57	.65	.72	.78	.83	.88
Duration of Fixation (in msecs)	330	300	280	270	270	270	270

Grade	8	9	10	11	12	College
Fixations	109	105	101	96	94	90
Regressions	21	20	19	18	17	15
Perceptual span (in words)	.92	.95	.99	1.04	1.06	1.11
Duration of Fixation (in msecs)	270	270	270	260	250	240

The units for fixations and regressions are not given (120 fixations per page?) but are included so a developmental trend can be observed.

The regularity of the increase for the first three

variables is striking. The relatively set time for fixation duration by grade four is just as striking. Tinker (1962) corroborates Taylor's mean adult duration of fixation with his figure of 250 msecs. He also gives a mean saccade time of 15 msecs., and a mean sweep time of 45 msecs.

The importance of these findings for this paper is that, for inclusive reading, almost all of the rate increase from grade four to college is accompanied by an enlarging perceptual span and a decrease in the number of regressions. That is, the unit of analysis (reflected in size of the perceptual span) increases developmentally. Since there is almost no evidence of speed readers having phenomenally large perceptual spans, and lack of regressions would only moderately increase rate, it seems that speed readers must be sampling the text to read so rapidly. Further evidence of this is presented at the end of this section.

Acuity

Foveal vision (100% acuity) covers only 7 to 10 letter spaces around the fixation point, and saccadic eye movements are so fast that no clear vision is possible during a saccade (Tinker, 1965). Acuity drops off rapidly from the fixation point. At 13 inches, letters one-half inch either side of the fixation point are seen with about 50% acuity. At one inch away, acuity drops to about 30% (Taylor, 1962b).

Peripheral vision (the vision surrounding foveal vision), and its role in reading, is currently under some debate. McConkie and Raynor (1973, 1974) have established that different information can be perceived at varying distances to the

right of a fixation: word length information, 14 or more spaces away; word shape and letter detail information, 10-12 spaces away; word meaning information, 4-6 spaces away. This last figure is an indicator of perceptual span as the term has been used by other researchers. The literature is almost devoid of any evidence of perceptual spans larger than about 2.5 words, and they are very rare (Taylor, 1962b).

Evelyn Wood's pamphlets lead one to believe that the perceptual span of her graduates is a page wide. There is no evidence of this. This use of peripheral vision is in disagreement with Mackworth's (1971) conclusion that peripheral vision may be used not for taking in information, but for determining unwanted information.

Eye Movements of Speed Readers

Eye movements of speed readers have been photographed and analyzed. Thomas (1962) reports the eye movements of a female professor reading a semi-technical book at 10,000 WPM. Her eyes started at the top of the left page in the middle of the line, went nearly straight down the middle of the page to just below the mid-point, crossed straight across to the middle of the right page, and went straight up to the top of the right page. There were no fixations on the lower third of each page, and she only averaged six fixations per page. There was no test of comprehension.

Taylor (1962a), in examining eye movements of 41 graduates of the Wood Reading Dynamics program, found that when Ss read "dynamically" from a novel, they averaged 31 fixations for a 30-line page. Fixation duration was a typical 250 msecs.

They did not read straight down the page. Their eye movements were arhythmical, very similar to eye movements produced during skimming or scanning. Spache (1962) came to a similar conclusion after photographing eye movements of speed readers. McLaughlin (1969) reports an S reading at 3,500 WPM with 14 fixations per page of 260 words, distributed in a rough zig-zag down the page. Finally, Kluska (1971), cited in Gibson and Levin (1975, p. 547), says eye movements of 'dynamic' readers following their hand "defy summarization."

Schale (1965) and McLaughlin (1969) feel speed readers are able to utilize a vertical perceptual span. The latter reports that his subject, when viewing a book through a camera shutter, reported up to seven words or phrases, which were as far as 10 inches apart, contained in a circular area up to 2 inches in diameter. This is the only evidence of a speed reader having a very large perceptual span. And it is not known if the span maintained its size when the person was speed reading a text rather than looking at a single tachistoscopic presentation.

It seems certain that speed readers are using a skimming strategy. Eye movement photography of speed readers has shown that they make relatively few fixations per page. Since fixation durations of inclusive reading and skimming are very similar, and there is very little evidence of large perceptual spans, speed reading rates must be achieved by skipping some of the text. The claim by Wood Reading Dynamic Institutes that their graduates read every word has

not been substantiated.

Tinker (1958), Spache (1962), and Taylor (1962b) have all hypothesized that the absolute oculomotor limit for reading inclusively is 800-900 WPM. Any rate beyond this must be skimming. This rate was derived by using the shortest fixation duration, shortest saccade, shortest return sweep, largest perceptual span, and no regressions. It is not likely that all of these co-exist in any one human being.

While 900 WPM may be an oculomotor limit, it is not known if the brain can handle language at that rate. Carver (1971) cites Carroll's (1967) hypothesis on a maximal rate of comprehension by reading.

> It is often claimed that comprehension can hold up even with fantastically high rates of reading perception speed, but to my knowledge there has never been any accurate appraisal of this claim. Suffice it to say that reasonably good comprehension can apparently hold up to speeds up to something like 500 words per minute, but even this statement is true, probably, only for relatively easy materials and for highly intelligent readers. (p. 42)

Conclusions on Rate of Reading

Based on the studies reviewed, the average rate of inclusive reading for adults on most materials, for most purposes, probably ranges from 185 to 300 WPM. The maximal rate of inclusive reading was hypothesized to be limited to 900 WPM by the efficiency of the oculomotor system. But the maximal reading intake rate of the brain has not been established. The comprehension/rate curve for individuals reading inclusively or skimming has not been well-established.

IV. Rate of Auding

Introduction

This brief introduction to time-compressed speech is a distillation of an article by Foulke and Sticht (1969) and a dissertation by Cramer (1968). Time-compressed (or simply compressed) speech is recorded speech which has been reproduced in less than its original production time. Since speakers can articulate words in connected discourse only to about 275-300 WPM (Goldstein, 1940; Sticht et al., 1974), compressed speech is necessary for faster presentations.

Basically, there are two common methods of speech compression; the speed-changing method and the sampling method. The speed-changing method involves playing a record or tape at faster than its recording speed. There is a resulting rise in vocal pitch which has been dubbed a "Donald Duck" or "chipmunk" effect. If the speed is doubled, vocal pitch will rise one octave.

The sampling method is used almost exclusively in present studies using compressed speech. Described by Fairbanks, Everitt, and Jaeger (1954), regular periodic samples of a recorded signal are reproduced in order and with temporal contiguity by a special sampling recorder. That is, very short segments of recorded speech are discarded and the remaining segments are electronically spliced together. The desired amount of compression determines the ratio of sample interval to discard interval. Since the discard interval is 40 msecs. long, a complete speech sound is not discarded. This method, also possible by computer, does not raise pitch.

There is a lack of common terminology in specifying the amount of compression used in studies. Thirty percent compression means that 30% of the production time was saved. Thirty percent of the original signal remaining means that the message is presented in 30% of the production time. An acceleration of 1.3 means that the word rate after compression is 1.3 times the word rate before compression. Whenever possible in this section rates in WPM will be given before and after compression. It should be noted that, with the sampling method, a doubling of rate involves loss of half the speech signal; a tripling of rate involves loss of two-thirds of the speech signal (Allen, 1967).

Why study high rates of auding when auding rates in everyday situations vary from 125 to 200 WPM (Foulke and Sticht, 1969; Sticht et al., 1974)? Much of the research has been geared toward exploring the usefulness of compressed speech for the blind. Also, in the audio-visual field, researchers are interested in establishing the efficiency of various rates of auding for various populations. A review of compressed speech literature is seen as necessary for this paper because a comparison of rates of reading and auding will necessitate some auding passages being compressed to a rate faster than speakers can articulate passages, to be comparable to a fast reading rate.

Studies on the Effect of Rate of Auding on Comprehension

Generally, the method used to study the effect of auding rate on comprehension has been to present a message recorded at different rates to Ss randomly assigned to aud one rate.

The message is a recording of a person reading aloud written language. Ss are then tested for comprehension, and the mean comprehension scores are compared between rates.

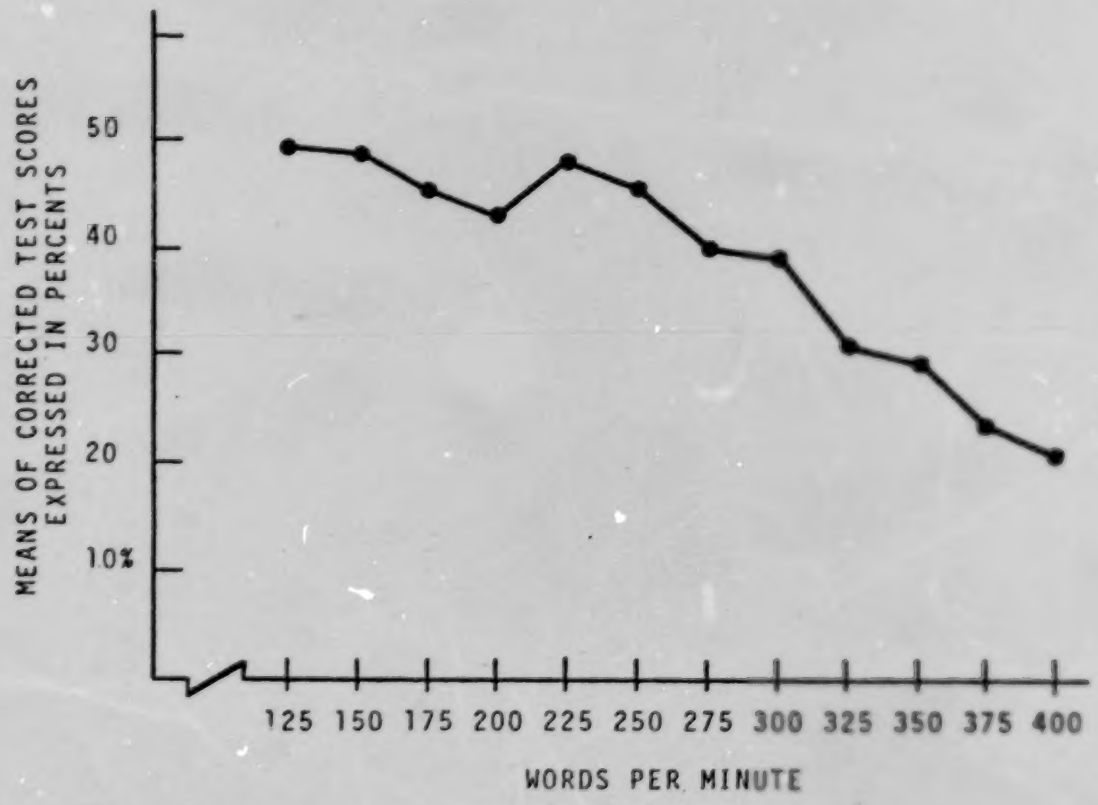
Fairbanks, Guttman, and Miron (1957b), cited by Orr, Friedman, and Williams (1965), used expositions of technical information as the stimulus, originally recorded at 141 WPM, which was compressed to various rates. Comprehension was tested by means of factual tests. At 282 WPM comprehension scores were 90% of maximum comprehension scores (those at 141 WPM). At 313 WPM comprehension scores were only 50% of maximum. However, McCracken (1971) presented 8 passages and test questions from the Diagnostic Reading Tests to 180 Ss, ages 19 to 22. There was no significant difference in mean comprehension scores resulting from auding the uncompressed passage rate of 160 WPM and the compressed rate of 320 WPM. Heise (1971) reports similar results. He recorded the 8 passages of the Nelson-Denny Reading Test at about 163 WPM, then compressed them to various rates. Ss (120 college students in 12 groups) auded the passages at one rate, and took the comprehension questions after each passage. Between 163 WPM and 325 WPM, scores dropped 6 percentage points. Then scores declined severely.

Foulke (1968) divided 360 college students into 12 groups. A 2,925-word passage, appropriate in difficulty and interest for a college population, was recorded and compressed to rates from 125 to 400 WPM in steps of 25 WPM. Each group of 30 Ss auded the passage at a different rate. To test comprehension, a 50-item multiple-choice test was administer-

ed after auding the passage. A correction for guessing was applied to the raw scores. The following figure describes the decrease in mean corrected comprehension scores as rate increased.

Figure 1

Mean Comprehension Scores as a Function of Auding Rate



(Foulke, 1968)

It can be seen from figure 1 that comprehension scores decline somewhat to 250 WPM, then the decline accelerates. This point, somewhere between 250 and 275 WPM, will be referred to as a threshold.

The significance of the differences between ordered pairs of individual means was examined by using the Newman-

Keuls Test for Ordered Pairs of Means. The following table lists significant differences.

Table 5

Newman-Keuls Analysis of the Significance of Difference Among Group Means

WPM	125	150	175	200	225	250	275	300	325	350	375	400
125							*		*	*	*	*
150									*	*	*	*
175									*	*	*	*
200									*	*	*	*
225									*	*	*	*
250									*	*	*	*
275											*	*
300											*	*
325											*	*
350												*
375												
400												

*(p<.01) (Adapted from Foulke, 1968)

It is clear from this table that losses in mean comprehension scores generally do not reach statistical significance until a rate of 325 WPM is reached. Comprehension scores at the 275 WPM rate were barely significantly different from the 125 WPM scores.

Carver's (1973a) extensive reanalysis of Foulke's data, largely examination of the comprehension test, showed that a comprehension/rate curve, as well as any threshold, may well be an artifact of traditionally developed tests. Carver's study will be treated more fully in a later section on problems of testing language comprehension. For now it is worth noting that Carver concludes "there is empirical evidence to support the hypothesis that a threshold is involved in time-compressed speech" (p. 24).

Since compressed speech is often an unfamiliar stimulus,

Orr, Friedman, and Williams (1965) designed an experiment to see if just listening to compressed speech would increase comprehension scores. Thirty-two undergraduates were put into groups matched for reading scores. The experimental group listened to 8-10 hours of novels at 325-475 WPM. The control group had no such practice. On a posttest on material unrelated to the practice sessions, the experimental group's mean comprehension score was significantly higher than the control group's score at 425 and 475 WPM ($p<.001$). They found wide individual differences within both groups. As an example of the comprehension/rate tradeoff, at the 425 WPM rate, the experimental group's mean comprehension score was about 78% of their 175 WPM mean comprehension score. The control group's mean score at 425 WPM was only about 49% of its 175 WPM mean score. So while it appears that comprehension of compressed speech can be trained, a comprehension/rate tradeoff is still evident, which varies with training.

Perhaps the most comprehensive review of the literature of comprehension of compressed speech is by Poulke and Sticht (1969).

> These studies indicated that a rapid decline in comprehension commences beyond a word rate of approximately 275 wpm, regardless of the compression which may have been required to achieve that word rate. (p. 52)

Intelligibility of Compressed Speech

Intelligibility of speech may be thought of as analogous to legibility of writing. There has been a good deal of research on the intelligibility of compressed speech which will just be reviewed very briefly here. Basically, it is

important to try to ascertain what influence declining intelligibility has on comprehension, as rate is increased. That is, at high rates, what proportion of comprehension loss is due to lack of processing time, and what proportion is due to stimulus degradation, or loss of intelligibility?

Cramer (1967) reports that one college student, when presented with the sentence, "Does a cow have kittens or horns," understood it to be "Does California grow the orange?" Here is a clear instance where intelligibility affects comprehension.

Foulke and Sticht (1969) have reviewed the literature on intelligibility of compressed speech. Several studies have indicated that, for lists of isolated words, compression to about 15% original time yielded an intelligibility score of about 55% (percent of words correct). Foulke and Sticht (1967a, 1969) and Heise (1971) found that intelligibility was affected less than comprehension by increasing compression. That is, as compression increased, intelligibility fell off less rapidly than comprehension scores. Other findings are that short phrases are more intelligible than isolated words, words with more phonemes are more intelligible than those with fewer phonemes, common words are more intelligible than less common words, and words presented via headphones are more intelligible than those presented via loudspeakers.

Foulke and Sticht (1967b, 1969), while admitting that decreased intelligibility might be expected to interfere with comprehension to some extent, draw the following conclusion:

> The fact that increasing the amount of comprehension has a different effect upon comprehension than upon intelli-

> gibility suggests that decreased intelligibility is not, in itself, an adequate explanation for the loss in comprehension. (1967b, p. 19)

But this assumes that there is a linear relationship between intelligibility and comprehension, which has not been established.

A study by Overman (1971) argues for Foulke and Sticht's reasoning that the sharper decrease in comprehension scores beyond 275 WPM is due less to intelligibility loss than to information processing demands. She recorded the eight passages of the Nelson-Denny Reading Test at 175-200 WPM. She then compressed them to 250, 325, and 400 WPM. On another tape, she added pauses between the phrases and the sentences of the compressed versions, such that the overall presentation time was increased up to the original presentation time. In other words, the time saved by compression was put back into the tape between phrases and sentences; the phrases themselves were still presented at the same rates as on the unaltered compressed tape. Thus, since the words on this third "time restoration" tape should have their intelligibility affected at the same levels as those on the unaltered compressed tape, any difference in comprehension scores between the two should be attributable to different amounts of auder processing times, not different degrees of intelligibility. A basic assumption was that the increased emphasis on phrasing in the time-restoration tape didn't increase intelligibility. One-hundred twenty university students were assigned to aud either the unaltered compressed tape or the time-restoration tape. Based on mean scores resulting from

answering the 36 questions on the test, the time restoration group had significantly higher scores at the 250 and 400 WPM rates ($p<.05$). Their scores at the 325 WPM rate were higher, but did not reach significance. It is possible to interpret these results as evidence that loss of processing time results in lower comprehension scores, but, since both sets of mean scores declined with rate increase, it is not the only factor affecting comprehension. While intelligibility seems to be a factor in comprehension at higher rates, its effect on comprehension has not been ascertained.

This discussion so far has been following the assumption that reduced intelligibility should lead to reduced comprehension. It may be that the relationship is more like a two-way street. An analysis by synthesis model of language comprehension (by auding: Halle and Stevens, 1964; by reading: Goodman, 1967, Hochberg, 1970) argues that the auder or reader makes predictions about what the input should be, then checks out the elements of the input only as thoroughly as is needed to confirm (sooner or later) a prediction. The import for this paper is that, under this model, not only should intelligibility affect comprehension, but comprehension should affect intelligibility. That is, once a sentence is comprehended, individual words should become more intelligible. Perhaps this accounts for the finding that compressed phrases are more intelligible than single words compressed by the same amount.

In summary, the relationship between intelligibility and comprehension is not clear, and is much more complex

than it first appears.

> The limit on listening to speech appears to be about 400 wpm ... though it is not yet clear whether this is a human limit on reception (or comprehension) or a machine limit beyond which the process used for time compression has seriously distorted the speech signal. (Cooper, 1972, p. 26)

Conclusions on the Effect of Rate of Auding on Comprehension

First, since just auding compressed speech tends to increase comprehension scores on subsequent material, it would seem justified for future studies to provide an adaptation passage for naive auders to familiarize them with compressed speech.

There does seem to be a comprehension/rate tradeoff. Generally, comprehension scores decline slowly with increasing rate until perhaps 275 WPM. Then the decline accelerates. This threshold seems to vary with Ss, even though almost all the studies have dealt with a rather homogeneous population -- college students. And this threshold may well be a function of the dependent variable, a comprehension test, often experimenter-designed.

The role of intelligibility in the decreasing comprehension scores is not clear. It seems that intelligibility (as tested by word recognition) holds up with increasing rate better than comprehension scores. But the real question, what proportion of comprehension loss at various rates is due to intelligibility loss, is unanswered.

V. Studies Comparing Rate of Reading versus Rate of Auding

Introduction

There are only a handful of studies which directly compare rates of reading and auding. In this section of the paper, I will review the studies and the results as they are reported by experimenters in some detail, note weaknesses in the studies, and attempt to synthesize the results across studies. Problems resulting from the tests of comprehension will be covered in Section VII.

Studies

1. Mowbray (1953) compared reading and auding comprehension on passages of three levels of difficulty, at 175 WPM.

Subjects: The subjects were 12 undergraduates and graduates, and 10 high intelligence British Navy men.

Materials: There were a total of 54 passages used, consisting of generally unfamiliar prose fiction, ranging from 154 to 220 words in length. The passages were chosen so that they fell equally into three categories: easy, medium, and difficult (as rated by Mowbray, using the Flesch readability formula). For the auding condition, the passages were recorded on tape at 175 WPM. For the reading condition, the passages were typed in a continuous line on a roll of paper. The print therefore moved from the right to out of view at the left, at a 175 WPM rate, and was viewed through a slot revealing six inches of the line of text at a time. The comprehension test for each passage consisted of 10 true-false items, mainly testing recall of facts, but some items

tested "general understanding."

Procedure: All the passages presented to an S were either read or auded. It is not stated whether Ss were randomly assigned to the treatment, or if they were presented all 54 passages. After each passage presentation, they took the comprehension test.

Results: While a test of significance was not used to analyze the data, it can be seen from the following table that the mean comprehension scores are very similar. Also, mean comprehension scores increased as passages became easier.

Table 6

Mean Comprehension Scores by Reading or Auding as a Function of Passage Difficulty

Passage Difficulty	Mean Comprehension Scores (% correct)	
	Reading	Auding
Difficult	60.8	63.3
Medium	67.4	67.3
Easy	74.0	73.1

(adapted from Mowbray, 1953)

Reaction: There are quite a few problems with this study. Random assignment to treatment is essential to draw any conclusions. and that is unknown. And the sample size (N=22) is relatively small. The moving reading stimulus is not natural; the eyes are forced to pursue the words to make a "fixation." It seems wise not to generalize too widely from this study, but, at 175 WPM, comprehension scores by reading are approximately the same as comprehension scores by auding.

2. Young (1973) also compared reading and auding comprehension at 175 WPM and obtained similar results.

Subjects: Two hundred eleven undergraduates were randomly assigned to one of the three groups: 90 to an experimental reading group, 90 to an experimental auding group, and 31 to a control reading group. Each group had about the same number of males as females.

Materials: The stimuli in both modalities were 14 informative passages used in a listening test developed by Rossiter (1971). Each was about 90 seconds long (which translates into about 263 words), and covered a variety of topics. All 14 passages were put on audio tape (with 14 different speakers) and 16mm motion picture film, so that presentation rates were at 175 WPM. The film presented the passage so that one line was visible at a time.

The test for each passage consisted of six multiple choice items. Two of the items tested the ability to recall facts, two items tested the ability to recall ideas, and two items tested the ability to generate valid inferences. Available reliability data indicate that the three subtests (each comprised of the total of 28 items testing one of the above abilities) correlate .50 with each other, and about .80 with the total test. Internal consistency of the total test is about .80.

Procedure: Instructions were given orally, then a practice passage and test were given. The passages were presented in random order for reading or auding, with two minutes being allowed between them to read and answer the six ques-

tions. One week later, Ss took the test again, without reading or auding the passages. The control group read the passages from printed pages, at their own rates, and only took the immediate test. They completed the passages and test in about 75% of the experimental group's time.

Results:

(a) There was no significant difference between the mean reading and auding scores of the two experimental groups on any of the three types of items, on either the immediate or delayed tests.

(b) The delayed test scores were significantly lower ($p<.001$) than the immediate test scores, and almost all the variance was due to the items testing recall of facts and ideas.

(c) Control group immediate test scores were higher than the experimental reading group immediate test scores (recall of fact items were significantly different; recall of ideas items were nearly significant ($p<.05$)).

Reaction: No rationale is offered for using 14 speakers on the audio tape; it would seem that this could only increase the differences between the two stimuli.

The film presentation of one line at a time may have interrupted normal eye-movement behavior. The control group test scores and total reading/testing time indicate that the film presentation is less efficient than reading from printed pages. However, the reading rate of the control group was not controlled, so it is difficult to make a comparison. They may have read the passages at the same rate, but answered

the questions much faster. At any rate, it seems that presenting one line of text at a time could greatly reduce the spatial nature of printed text, perhaps resulting in different reading strategies than when reading full pages of text.

This study substantiates the more tentative conclusion drawn from Mowbray's study that, at 175 WPM, mean comprehension scores by reading or by auding are comparable.

3. Goldstein (1940) compared reading comprehension with auding comprehension at seven rates in a complex study.

Subjects: Two-hundred eighty male and female Ss were studied, ranging from 18 to 65 years old. There was a good deal of variability in cultural background and various standardized test scores such as IQ and educational achievement scores. Mean intelligence and achievement scores were above average; the mean reading comprehension level was about grade equivalent (G E) 9-10.

Materials: There were 28 passages, ranging in length from 119 to 213 words, which were chosen from the McCall-Crabbs Standard Test Lessons in Reading. These were described as 14 easy passages (3.5 GE if questions 50% correct) and 14 hard passages (7.5 GE if questions 50% correct). For the reading stimulus, each of the 28 passages was put on film, so that 10 lines were on the screen, and so that the print moved up and off the screen one line at a time to pace the reader. For the auding stimulus, a male speaker who had won a diction award recorded each of the 28 passages at each of the following rates: 100, 137, 174, 211, 248, 285 WPM. The record playback speed of the 285 WPM rate was increased to make a final rate of 322 WPM. The film and record duration

times were equal for the same passage at each rate.

The comprehension test items were the multiple-choice items from the McCall-Crabbs passages, testing recall of detail and the ability to make inferences. The examiner added one or two questions to some passages, resulting in about 11 items per passage.

Procedure: Passages and rates were presented in random order to groups of 10, such that half the presentations required reading, half auding. Since every S could not be presented with every passage at every rate in both modalities (392 combinations), an overall counterbalanced design was used. After each presentation, the comprehension test was read and answered by Ss; there was no test time limit.

Results:

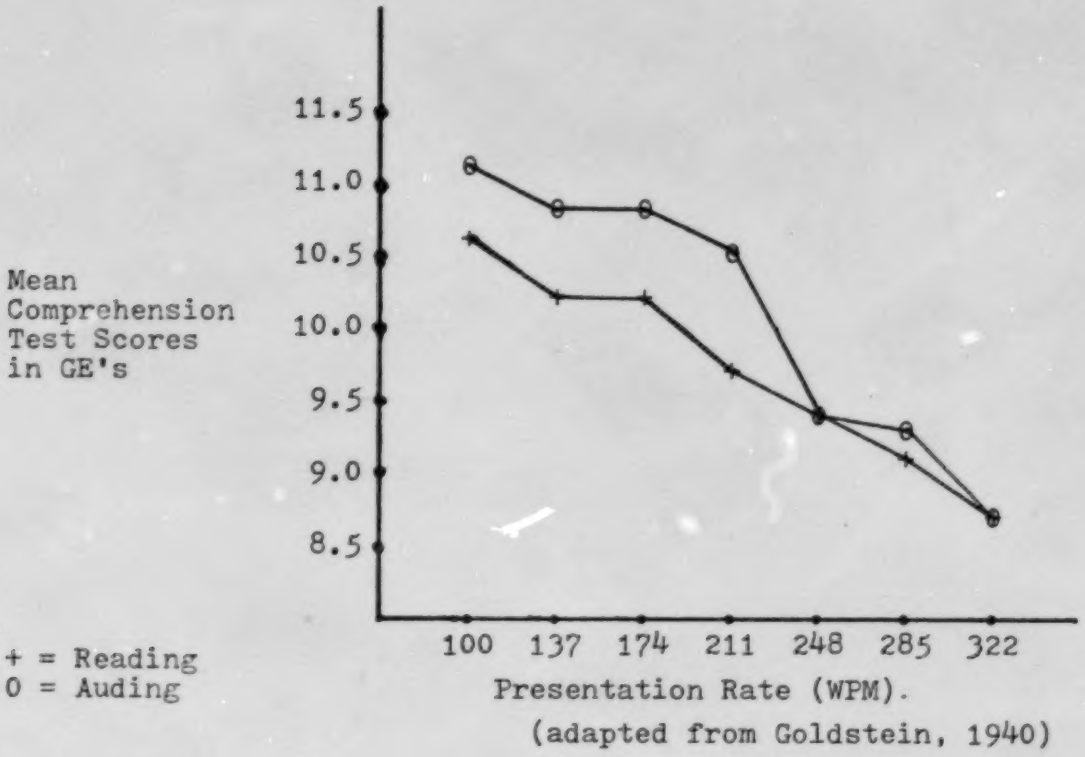
(a) Summing across both difficulty levels of material, all rates, and all Ss, auding comprehension scores were significantly higher ($p<.01$). Mean auding comprehension GE was 9.8. Mean reading comprehension GE was 9.5. Most of the variance was in the easy passages. The results are presented in figure 2.

(b) The relative superiority of auding is inversely proportional to intelligence and performance on a reading rate test. That is, the superiority of auding over reading was less for the higher intelligence Ss and faster readers.

(c) Comprehension decreases for both modalities as rate increases; optimal rates are not manifested. This comprehension/rate tradeoff was evident in auding comprehension scores more than reading comprehension scores, and was evi-

Figure 2

Mean Comprehension Test Scores by Reading and Auding as a Function of Presentation Rate



(adapted from Goldstein, 1940)

dent on difficult passages more than on easy passages.

(d) The reading scores correlated rather highly with S's standardized reading test scores (upper .60's to upper .70's), suggesting that the film presentation is not radically different from reading a printed-page test.

Reaction: Generally, this is a well-designed study, with a sample more representative of the universe of adult readers than is usually found. The rates were precisely controlled, and each passage was presented at all different rates, and in both modalities.

However, the moving print on the film may have made

the reading stimulus decidedly different, and perhaps slower, than normal reading of printed text. Also, the 13% speed increase necessary to achieve the 322 WPM auding rate results in a frequency shift, which makes the stimulus at that rate unlike the stimulus at slower rates.

4. Jester and Travers (1966) studied rate of reading, auding, and simultaneous reading and auding. Only the reading versus auding comparison will be reported here.

Subjects: The sample was comprised of 120 undergraduates who were run in groups of two to six.

Materials: Eight passages from the Davis Reading Test, Form IA were used; they ranged in length from 17 to 390 words, with a mean length of 144 words. The test is designed for students in grades 11 and 12, and the first year of college. The auding versions of the eight passages were prepared on audio tape at rates of 150, 200, 250, 300, and 350 WPM. The 150 WPM tape was non-compressed speech; the others were compressions of a 175 WPM tape. The reading versions of the eight passages were on slides, with one or two sentences per slide. Slides were advanced at a pace to make the total passage reading time equal to the total passage auding time at each rate.

The comprehension test items were the 45 multiple-choice items (total of the items from the eight passages) from the Davis Reading Test. Forty additional Ss were given the questions without seeing the passages and scored significantly higher than chance level. On this basis, a correction factor was formulated which was applied to the scores of the

data-producing sample.

Procedures: The two modes and five rates comprised a 2 x 5 factorial disign. Twelve Ss were randomly assigned to each cell. Hence, the 12 Ss in each cell were presented all eight passages in one mode and at one rate. The Ss were given instructions in the same mode as the experimental passages. After each passage, they were given sufficient time to read and answer all the comprehension items for that passage.

Results:

(a) Generally, mean comprehension scores of the two modes decline with increasing rate, although in neither mode is this a simple linear relationship.

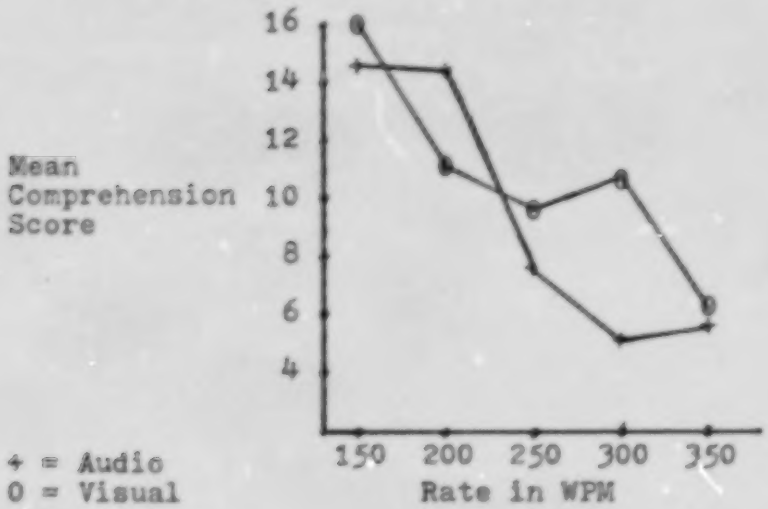
(b) Auding comprehension scores are superior to reading comprehension scores at 200 WPM, but the reverse is true at 300 WPM. They are nearly equal at 150 and 350 WPM.

Figure 3 indicates the above results.

Reaction: This study seems methodologically sound. But some of the passages are quite short; the 17-word passage at 350 WPM takes less than three seconds to present. In short passages, redundancy is reduced due to lack of prior information on which to build accurate predictions of subsequent text. Thus, more careful reading or auding of short passages may be necessary, since on longer passages greater redundancy should facilitate more accurate predictions and faster processing. If more careful reading or auding is not possible due to time constraints (for those Ss in cells at higher rates), comprehension scores may decrease.

Figure 3

The Effect of Rate and Mode of Presentation upon Comprehension



(adapted from Jester & Travers, 1966, p. 299)

The slides eliminate the problem of moving text and breaking up sentences. Yet they don't contain nearly as much text as is found on the page of a book. The slide-change interruption every one or two sentences may slow reading and reduce the sense of continuity of a passage.

5. Carver (1973b) compared rates of reading versus auding, and measured the effects on four comprehension tests.

Subjects: The sample was comprised of 108 paid college students.

Materials: Ten passages from the Carver-Darby Chunked Reading Test comprised the stimuli for both modalities. Each passage is about 325 words long, written for adults and students in high school and college.

For the auding treatment, all the passages were recorded and compressed to 150, 200, 250, 300, 350, 400, and about

450 standard words per minute (SWPM). Two additional rates, 75 and 100 SWPM were obtained by playing the 150 or 200 SWPM tapes twice. To control for varying word lengths, Carver defines a word by a standard word length of six letter spaces.

For the reading treatment, Ss read from printed pages. It should be noted that the reading rate was not directly controlled; the readers were told they would not know how long they would have to read each passage, but that they should read at their normal rates until told to stop. The time allowed for reading was the same as for the corresponding auding passage at the same rate; if readers finished before time was up, they could reread.

There were four tests of comprehension:

(a) Subjective rating of understanding. All Ss, just after reading or auding the passage, estimated the percentage of complete thoughts in the passage they understood. A thought was defined as a sentence.

(b) The items from the Carver-Darby Chunked Reading Test. Each passage was divided into 100 chunks (one to five meaningfully related words). At random, one of every five chunks was rewritten to make a semantic change from the passage; Ss had to identify the changed 20 chunks when rereading each passage as a test.

(c) Cloze technique (20%). Every fifth word was deleted from the passages; only 20 random clozes from the total 65 were scored, to maintain 20 items per passage.

(d) Modified cloze technique (40%). Every fifth and sixth words were deleted; the same 20 items as above were scored.

Procedure: Half of the Ss were randomly assigned to one of five reading groups, half to one of five auding groups. They were given a practice test, then presented the 10 passages at the 9 rates in a counterbalanced design. The tenth "passage" involved taking the test without reading or auding the passage. Immediately after each passage, every S estimated his understanding of it. Then each third of the Ss read and answered one of the three objectively scorable tests, within a six-minute time limit.

Results:

(a) There was a generally linear decline in all comprehension scores as rate increased, for both modalities.

(b) This decline varied greatly by instrument. While understanding ratings declined 80%, chunk test scores declined 60%, and both cloze test scores declined only about 20%. (Scores on the modified cloze test were the same at 150 SWPM as when Ss were not previously presented the passage.)

(c) The correlations between the three objectively scorable test means and the ratings of understanding means were high: .75 to .99.

(d) On the basis of chunk test scores (the most sensitive and objectively scorable), auding and reading scores are nearly comparable to 200 SWPM. Beyond this (except at 300 SWPM), reading assumes an increasing superiority (N=36). The results are displayed in Figures 4 and 5.

Reaction: Some methodological problems need to be pointed out. The reasoning that two presentations at 200 equal one presentation at 100 SWPM is questionable. Perhaps

Figure 4

Mean Reading Test Scores as a Function of Presentation Rate for the Chunked, 20%-Cloze, and Revised Cloze Tests

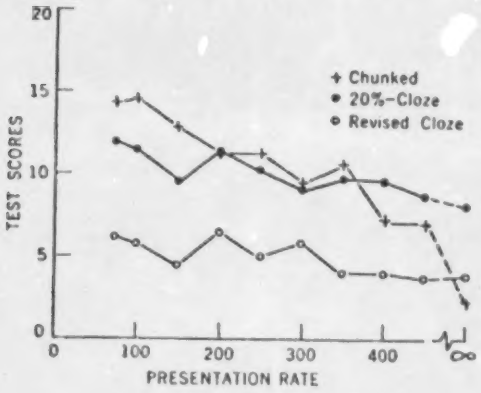
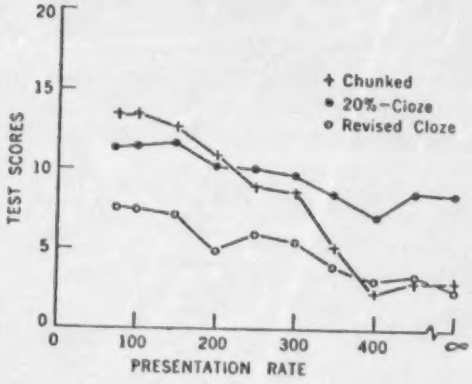


Figure 5

Mean Auding Test Scores as a Function of Presentation Rate for the Chunked, 20%-Cloze, and Revised Cloze Tests



(Carver, 1973b, p. 80)

the data generated from the 75 and 100 SWPM rates are not comparable to the data from the higher rates, where Ss had one presentation.

Carver allowed Ss to read naturally from the printed page, but he lost control of reading rate. There is no way of knowing if Ss read the "200 SWPM" passage twice at 400 SWPM, or if they failed to finish reading. Since they were told to read at their normal rates, it is unreasonable to expect that they actually read at rates varying from 75 to 450 SWPM over different passages. This indirect control of reading rate doesn't allow a reading versus auding comparison at specific rates, or a reading comprehension/rate comparison. What the reading scores at increasing rates probably show are decreasing percentages of the text actually read under shorter time limits.

6. Carver (1976) has subsequently made another study on the effect of rate of reading and auding on comprehension, but with the emphasis on identifying an optimal (most efficient) rate of reading and auding. Efficiency is defined as a product of accuracy and rate.

Subjects: The sample was comprised of 102 paid college students.

Materials: Carver used 80 different passages, which Bormouth (1969) had previously sampled from curriculum materials. The 100-word passages were from four difficulty grade levels: 5, 8, 11, and 14. At each level, there were 20 passages.

For the auding treatment, the passages were recorded at about 167 SWPM and compressed by the sampling method to about 209, 250, 292, 333, 376, 417, and 500 SWPM. An additional rate of 83 SWPM was obtained by playing the original tape twice. For the reading treatment, the passage was filmed such that, when projected, it remained stationary on the screen, while a masked "window" three lines in height paced the reader by moving down the screen at a speed corresponding to the auding rates.

There were three tests of comprehension for each passage:

(a) a subjective rating of understanding, which all Ss did.

(b) a reading-storage test of 10 items per passage, which half the Ss received. This test apparently was an application of the previously-described chunked test

principles to these passages.

(c) a multiple-choice test, which the other half of Ss received. The focus was upon writing four-alternative items that couldn't be answered correctly without the passage being presented, but could be answered correctly if the passage had first been presented at about 150 SWPM. The idea was to minimize the possibility of correctly guessing items.

Procedure: Ss had extensive practice sessions where they rated their understandings of passages, and read and auded other passages at all the rates. The 102 Ss were divided into 20 groups, and treatments were administered such that half the groups read 10 passages and auded 10 passages, both at difficulty levels of 5 and 14. The other half of the groups read 10 passages and auded 10 passages, both at difficulty levels of 8 and 11. So any particular S read 10 passages and auded 10 different passages within one difficulty level, then read 10 passages and auded 10 different passages within another difficulty level. There were nine possible rates, plus a condition where Ss took the test without being presented the passage. Each passage was presented in 5 of the 10 possible conditions. Passages and rates were in a counterbalanced order to control for order effects and passage/test differences within each grade difficulty. After each passage, Ss estimated their understanding of it, then took one of the two objectively-scorable tests for that passage.

Results:

(a) Again, the subjective ratings of understanding correlated highly with the objectively-scorable tests:

.86 to .98.

(b) Accuracy (mean comprehension scores) decreased with increasing rate for both modalities.

(c) There was little or no difference between mean reading and auding comprehension scores at any rate. The differences between means were not tested for statistical significance.

(d) An optimally efficient rate of reading and auding manifested itself when comprehension scores were analyzed. This rate was about 300 SWPM. Rates slower or faster than this were less efficient. That is, the optimal rate allowed the most sentences to be rated understood per minute. Carver calculates efficiency by multiplying mean accuracy scores by rate.

(e) The optimal reading rate appeared to be greater than the optimal auding rate by 10%-15% (30-40 SWPM). Carver feels this may be due to the technique used to manipulate reading and auding rate, primarily skimming during a reading presentation, and intelligibility loss on the auded passages by compressing speech.

(f) This same optimal efficiency rate manifested itself across all four difficulty levels of passages.

(g) "It appears that common central processing factors are limiting comprehension rather than factors associated with the sensory mode in which the information is presented" (Carver, 1976, p. 33).

Reaction: This study represents an improvement in methodology over the previous study, since reading rate was

directly controlled by the experimenter. Also, the reading material was not moving, which made it more approximate to a normal reading situation. The continued use of more than one method of testing comprehension is seen as advantageous; this is covered more fully in Section VII.

Though Carver makes the statement that comprehension scores do not differ (or only differ slightly) between modalities, it would be interesting to analyze the mean data at each rate, and test for significant differences. From figures provided in the manuscript, it appears that reading comprehension scores are higher than auding comprehension scores at the two fastest rates (417 and 500 SWPM). Of course, Carver's reasoning that any difference may be the result of speech compression may be correct, since only one-third of the original speech signal remained at 500 SWPM.

It is very interesting that the optimal rate of comprehension should remain constant from relatively easy material (grade 5) up through relatively hard material (grade 14). The common belief is that relatively easier material should allow more accurate comprehension at a faster rate (i.e. more efficiency) than harder material. However, Carver's finding is not as problematical as first appears. The optimal rate is for those comprehension scores <u>within</u> a difficulty level. Therefore, the optimal rate for comprehending a fifth grade passage yields a higher comprehension score than the same optimal rate for comprehending a college passage. That is, comprehension scores drop off with increasing difficulty of material, even though the optimal

rate of comprehension remains constant.

Conclusions on Rate of Reading versus Auding

1. For the four studies using different rates (Goldstein, 1940; Jester & Travers, 1966; Carver, 1973; Carver, 1976) there is general agreement that comprehension scores decrease as rate increases. In some studies, this relationship is nearly linear; in others it is not so clearcut.

2. There is no conclusive evidence of a comprehension threshold, a rate beyond which the decrease in comprehension scores accelerates. The evidence for a threshold by auding, between 275 and 300 WPM (Foulke & Sticht, 1969), is perhaps stronger than the evidence reviewed in this section for a threshold by reading. However, if a threshold is thought of as a point of optimal efficiency, Carver's (1976) study argues for a threshold at about 300 SWPM for both modalities.

3. The evidence for the relative superiority of one modality is inconclusive. At about 175 WPM, it seems safe to conclude that there is little difference between mean comprehension scores. At higher rates, there are conflicting results. It is impossible to present a composite figure of comprehension/rate curves by reading or auding because of the use of widely differing outcome measures, and because of differing methods of material presentation.

4. There are many problems in generalizing from these studies, which I have categorized below under three headings: subjects, materials, and procedures.

Subjects: Ss are usually college students; only Goldstein used a wide range of adult subjects. Often there are

only a few subjects per cell in a factorial design, and the resulting data are not tested for significance. No attempt has been made to study the auding rate of (a) rapid readers, to see if they are "rapid auders," or (b) slow readers, to see if they are "slow auders."

Materials: Materials vary widely in length and difficulty. The longest passage anyone used was 390 words; this would only cover perhaps 1½ double-spaced typewritten pages. Carver's use of "standard words" makes it difficult to compare his results with other results. Carroll (1967) has suggested using syllables per minute as a unit of rate, since words comprising more difficult passages tend to contain more syllables than words comprising easier passages. Therefore, even though an elementary level passage and a college passage may both be presented at 200 WPM, the college passage will probably present more syllables per minute. Finally, the test items may influence the comprehension/rate curves due to differing degrees of sensitivity to information gain from the material, making between-studies comparisons tenuous, and within-study results questionable.

Procedure: The reading presentations were on film, slides, and printed pages; some limited the amount of text available and each to a different degree. The auding presentations were always "book English" replayed on a recording device (non-compressed, compressed by speed changing, and/or compressed by the sampling method).

VI. Similarities and Differences of Print and Spoken Print

Introduction

As can be seen in the preceding section, the stimulus in those studies comparing rate of reading versus auding has been "book English," that is, written language which has also been read aloud. We will refer to print read aloud as, simply, spoken print, since it is not the same as spontaneous speech. The purpose of this section is not to list the differences between spoken print and spontaneous speech, but to consider the similarities and differences between print and spoken print, the stimuli used in the preceding studies.

It is important to detail the similarities and differences of print and spoken print when analyzing studies such as those in the preceding section. None of the experimenters discussed stimulus differences, so it is assumed that they felt any between modality variance was due only to modality efficiency. However, there are differences which must be considered.

The position of this paper is that similarities far outweigh differences, although it is admitted that the proportion of any variance between modalities attributable to stimulus differences cannot be quantitatively measured. That is, we are arguing that the stimuli are enough alike to make the sort of comparisons made in the preceding section.

Similarities

1. Both stimuli utilize the same conceptual base of the

receiver. It has been hypothesized that real world experiences are the bases for comprehending language by either modality, and reading and auding may add to the conceptual base (Dilena, 1975).

2. Both stimuli utilize the same semantic scheme. That is, the written word "butter" means the same as the spoken word /bədər/.

3. Both stimuli utilize the same syntax. The words and ideas maintain the same relationships.

4. Both have redundancy, related to the above three statements. That is, more cues are available in either modality than are absolutely necessary for the mature receiver to comprehend the meaning of the message. This implies that parts of the message may be skipped without a loss in comprehension, as telegram readers know. Language redundancy is on two levels -- semantic and syntactic (Weaver, 1962). Print also has orthographic redundancy (Niles, 1975-1976) while spoken print has phonological redundancy (Fairbanks, Guttman, and Miron, 1957a). The concept of redundancy is deserving of a paper in its own right, and its importance has been stressed and demonstrated by Goodman (1970), Lindsay and Norman (1972), Mackworth (1971), Martin (1973), Neisser (1967), and Smith (1971).

As evidence that the above similarities are valid, it is noted here that the same sentence(s) in either modality will result in the same conceptualization(s). And it has been found that the correlation coefficients between scores on reading and auding comprehension tests are quite high: up

to .80 (Spearritt, 1962).

Differences

Tables 7 and 8 provide a relatively self-explanatory presentation of stimulus and other differences in normal situations and in experiments controlling rate of presentation.

While the listing in these tables looks like an impressive array of differences, the contribution of many to a difference in comprehension scores is probably negligible. For instance, the fact that print utilizes a secondary symbol system while spoken print utilizes a primary symbol system would probably not contribute to higher or lower comprehension scores (assuming mastery of the secondary system).

Other differences can be largely controlled. For example, since print can make a homophone distinction and spoken print can't, it would seem wise not to use sentences such as, "the none tolled hymn they had scene and herd a pear of bear feat in the haul" (attributed to Jay Samuels).

Probably the major source which might contribute to different comprehension scores is the way the material is prepared for presentation in those studies which control rates directly. In the auding modality, increasing compression results in decreasing intelligibility. At the same time, the legibility of the passage in the reading modality remains unaffected, resulting in an advantage for this modality. Likewise, if the printed material is flashed one line at a time, or is in motion, this may result in an advantage for the auding modality.

Table 7

Differences between Print and Spoken Print in Normal Situations

Differences	Print	Spoken Print
Stimulus Differences		
Transmission energy (Sticht et al.,1974)	Electromagnetic	Mechanical
Level of symbols (Gibson & Levin, 1975)	Largely secondary (in alphabetic writing systems)	Primary
Dimensions	Spatial, permanent (allows sampling, preview, review-referability)	Temporal, transient (doesn't allow sampling, preview, review)
Stimulus redundancy	Orthographic	Phonological
Input rate control	Receiver	Transmitter
Additional cues (not available in other modality)	Punctuation, capitalization, italization, underlining, spacing	Pitch, pause, intonation, rhythm
Intensity	Can be increased by size, contrast, color, etc.	Can be increased by loudness
Advantages	Presenting "visual" information (directions, charts, what a quetzal looks like)	Presenting "auditory" information (what a quetzal sounds like)
	Allows homophone distinction ("cite, sight, site"), but not homograph distinction	Allows homograph distinction ("lead"= /led/ or /liyd/), but not homophone distinction
	Receiver may use peripheral vision for preattentive processing	
Other Differences		
Sensory receptors	Eye	Ear
Receptor orientation	Yes	No
Acquisition	Largely learned through formal instruction	Largely learned informally

Table 8

Additional Differences Possible
in Studies of Reading/Auding Rate

Differences	Print	Spoken Print
Stimulus Differences		
Stimulus degradation	No	Yes, if compressed speech is used (varies with % of compression, or with frequency shift)
Other stimulus differences (from commonest non-experimental occurances)	Material generally projected instead of printed on paper, possibly resulting in contrast change, perceptual span change and reduction in amount of text available Print can be in motion if projected by film Referability advantage reduced	Material generally tape recorded, resulting in a lack of human visual cues (primarily eye, mouth, gestures)
Other Differences		
Input rate control	Reader, when under time limit (examiner indirect control) Examiner, when presenting projected stimulus (examiner direct control)	Examiner

It is still argued that even these differences can be minimized in a study by not using severely compressed speech (by having the speaker on the original tape speak faster) or very atypical reading situations. Regardless of the modality, it is the same language. In studies of rate of reading versus rate of auding, the same words, sentences, and passages are presented to both modalities. This should be enough of a similarity to reveal any modality differences.

VII. Some Problems of Testing Language Comprehension

Introduction

One of the problems in interpreting the results of the studies reviewed in this paper is the differing nature of the comprehension tests. The literature on the assessment of comprehension is immense. In these few pages, this paper will review those problems which bear directly upon the topic of this paper. In general, I agree that "much of the problem of conflicting results may revolve around the problem of measurement.... In a sense we are measuring with something like 'rubber yardsticks'" (Orr, 1971, p. 219).

Characteristics of a Comprehension Test

The term validity, in its broadest sense, refers to the degree to which a test measures what it purports to measure. For our purposes, a comprehension test score should reflect only comprehension of the previous passage. The more that other factors (memory, guessing, etc.) affect a score, the less valid the test becomes.

For our purposes, the term reliability refers to the degree of stability a test score is likely to have. That is, we expect a good comprehension test to yield relatively consistent scores, so that variance in scores may be attributed to variance in comprehension between Ss, rather than imprecise measurement.

One of the problems in interpreting the results of the reviewed studies is that there is often no information on the validity or reliability of the comprehension test. Particu-

larly in the area of rate of reading, experimenters have designed their own instruments, without subjecting them to psychometric analysis before using them in a study. There is no way to tell what these tests were measuring, or if they would be likely to yield reliable results.

Methods of Testing Language Comprehension

The many varieties of methods of testing language comprehension are reviewed and analyzed by Carroll (1971). Three of these methods will be discussed here.

Probably the most common method is asking questions on material that has just been presented. These questions can be true-false, multiple-choice, short-answer, matching, or essay. It is absolutely essential to pretest these questions on a population similar to the one to be studied to obtain the real "chance level" of answering the questions without reading the material. On a four-alternative multiple-choice test, the statistical chance level is 25%, while the real "chance" level may be higher for some populations. Carver (1971) notes that some readers may answer questions correctly without reading the material by

(a) using general background knowledge.

(b) getting information from another question.

(c) eliminating obviously wrong choices.

In all fairness, professional test writers employ procedures to minimize at least the latter two sources. We have no way of knowing if a particular researcher-designed test attempted to control any of these sources.

Although the cloze technique has not been used to a great extent in reading and auding rate studies, Carver (1973b) explored its use in the study reported in Section V. He found that 20% and 40% cloze tests were relatively insensitive to comprehension loss measured by another instrument, as well as Ss judgments of understanding. One possible explanation is that Ss can use conceptual and language knowledge (in particular, the redundancy and constraints of language) to fill in the clozes.

Free recall is another method that has been used to assess comprehension. Its lack of objective scoring is seen as a threat to reliability, although it is possible to draw up an outline of points Ss must cover to receive credit. Its greatest advantage is probably that there are no questions or words which may serve as cues to right answers.

Foulke and Sticht (1967b), while reviewing studies on the rate of auding, report one study (Bellamy, 1966) that found a difference between two groups with an interview technique; this difference was not identified with a multiple-choice test. Another study (Friedman, Orr, Freedle, and Norris, 1966) found no improvement in comprehension after an auding treatment, as measured by short answer and essay tests. A multiple-choice test, however, revealed considerable improvement. They also found a lack of correlation between the short answer and essay tests.

Different methods of assessing comprehension have different weaknesses. Some methods may be much more sensitive to comprehension gain than others. As will be pointed out

below, it is difficult to put much faith in a study which reports no differences with one test, but which may have found differences with several other tests.

Comparison Problems Between Studies

Only the most tentative generalizations can be made between the studies which have been reviewed, because of the variety of comprehension tests used. Not only were the passages of various difficulties, but the mean item-difficulties of each test were probably different. For instance, a score of 50% on one test may have represented better comprehension than a score of 95% on another test. That is, some tests are "easier" than others.

A second problem is that some tests assess only recall of facts, others assess this plus the ability to make inferences and the ability to "reflect critically." There is no reason to assume that the former tests are comparable to the latter tests. Perhaps inferencing items may be more a measure of general cognitive ability than of language comprehension. Evidence for this is found in Young's (1973) study, reviewed earlier, which showed that inferencing items were relatively insensitive to the information loss over a week's time revealed by recall items. The different natures of the tests used in these studies indicate that the test designers are following different definitions of comprehension.

Finally, different tests often require different cognitive processes to answer. Multiple-choice tests often require recognition, while short-answer tests require recall. But even multiple-choice questions may require analysis,

synthesis, or evaluation, as anyone who has taken the Graduate Record Examination knows. It seems that requiring different cognitive processes to answer different test questions makes it difficult to compare comprehension scores between studies.

Problems within a Study

One of these problems has to do with describing a comprehension/rate tradeoff. That is, to what extent is any comprehension/rate curve, and threshold, an artifact of a test? As an example, Carver (1973a) reanalyzed Foulke's (1968) data on the effect of auding rate on comprehension at rates from 125 to 400 WPM (reviewed in Section IV). By plotting the percent correct for each of the 50 multiple-choice items of the comprehension test, Carver showed how the comprehension/rate curves varied widely between items. Indeed, the experimenter could create a variety of curves, depending upon the items chosen, as was demonstrated by Carver. By recalibrating the item scores, the acceleration of comprehension loss (threshold) Foulke noticed after 275 WPM was only one-third as severe. Here is some evidence suggesting that the measurement approach can confound the results.

Finally, it should be noted that the studies on the effect of rate of reading and auding on comprehension cannot present the same material and comprehension test twice to one S, once in each modality. The score of the second test may reflect comprehension gain from both presentations of the materials, resulting in a higher score. Consequently,

these studies are forced to rely on a counterbalanced experimental design, where easier and harder materials and tests will hopefully balance out. This necessitates analyzing the scores as mean data, since any one S may have received untypically easy (or hard) material or test questions. Individual data, and any resulting similarities and differences between individuals, is missing from these studies.

Conclusions

It may be possible to minimize the problems involved in comprehension testing by choosing a standardized auding or reading test, if validity and reliability are satisfactorily established. At least this would allow other researchers to examine the materials and test questions readily. It would also allow for the replications of studies.

And it may be advantageous to use more than one method of testing comprehension. For example, a free-recall test (with some measure of objectivity) might be used just before a multiple-choice test. Results which remained the same through several methods of testing should be viewed with more confidence than results employing only one method.

VIII. Summary and Conclusions

Introduction

This section will briefly try to summarize the results of the studies reviewed and to draw conclusions from these results. The results may be broken down into the two major purposes of this paper: to identify rates of reading and auding, and to describe modality efficiency of reading and auding. By now, it should be clear that no hard answers can be offered. The limitations of generalizing from the studies have been emphasized throughout the paper.

Rate of Reading and Auding

Ideally, the question of reading or auding rate should be qualified with a specific population, with a specific purpose, reading or auding specific materials which are assessed for comprehension with a specific test. There is evidence throughout this paper that all of the above affect the rate of reading or auding, and comprehension scores. Almost none of the reviewed studies have controlled S's purpose. However, it is concluded that the norm rate (defined as the most Ss, comprehending for most purposes on most materials) is in the neighborhood of 185 to 300 WPM for reading (Taylor, 1962a; Education Commission of the States, 1972; Nelson-Denny Reading Test norms). The norm rate for auding is in the neighborhood of 125 to 200 WPM (Foulke & Sticht, 1969; Sticht et al., 1974). It should be noted that norm reading rate is controlled by the reader (receiver), while norm auding rate is controlled by the

speaker (transmitter).

For maximal rates, the conclusions are more tentative. The maximal rate of auding may be somewhere in the range from 350 to 450 WPM, before comprehension scores drop to near chance levels. The effect of intelligibility on comprehension at high rates has not been accurately assessed. In reading, there is conflicting evidence on a maximal rate. The accuracy of comprehension of speed readers is under some debate; it has been shown that they are skipping a good deal of the text. If comprehension does hold up on a valid and reliable test, these readers must be making very accurate predictions about the skipped text, possibly by using prior knowledge, plus the redundancy and constraints of language. The studies reviewed examining comprehension at different reading rates versus different auding rates all noted a decline in comprehension scores as rate increased. What is to be defined as a "maximal" rate? Should it be one where comprehension scores are just above chance level? It is suggested that future studies select (arbitrarily) a comprehension score as a yardstick of "acceptable comprehension." When comprehension scores fall to this point, a maximal rate can be said to have been reached.

Modality Efficiency of Language Comprehension

Judging from those studies reviewed in Section V, it can be concluded that one modality does not have a clear-cut advantage over the other when mean scores are used. While there are, within studies, advantages reported for one modality, the advantages are small and might be accounted

for by experimenter-manipulation of the stimuli. Certainly there is no evidence that Ss can read at 10 times the rate they can aud, or even at twice the rate. A study which might be helpful in this area would be a study of comprehension at different reading and auding rates, using a population of very fast, accurate readers. If a reading modality advantage were likely to manifest itself, it would be likely to do so in this population.

Final Conclusions

The results of the reviewed studies are sometimes inconsistent, often inconclusive, and largely not generalizable to other populations, purposes, and materials. The summary of findings offered above is probably all that the data have allowed.

Future studies on the rate of reading and auding should be expected to:

(a) include detailed population parameters.

(b) describe in detail the stimuli, their preparation, and their presentations.

(c) describe and defend the method(s) of testing comprehension.

(d) randomly assign subjects to treatments.

(e) describe the procedures in enough detail to allow replication.

(f) test for significant differences the mean comprehension scores between modalities, at each rate.

By consistently following these desiderata, results from future studies should yield more accurate and reliable

answers to the questions asked in this paper.

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